Quantifying the Snowfall Detection Performance of GMI Channels and GPM Constellation Radiometers over Land

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Objectives:

- Quantify the snowfall detection performance of both low and high frequency channels
- Quantify the snowfall detection capability of the 13 GPM constellation radiometers

Six types radiometers (channel availability)

Radiometer type`	Radiometer name	6-7 GHz	10 GHz	19 GHz	23 GHz	31-37 GHz	50-60 GHz	80-92 GHz	150-167 GHz	183-190 GHz
Type 1: Low freq. channels	WindSat	6.8 V/H	10.7 V/H	18.7V/H	23.8 V/H	37.0 V/H				
Type 2: Low freq. channels +89 GHz	TMI	6.9 V/H	10.7 V/H	19.4 V/H	21.3 V	37.0 V/H		85.5 V/H		
	AMSR-E		10.7 V/H	18.7 V/H	23.8 V/H	36.5 V/H		89.0 V/H		
	AMSR2	6.9/7.3V/H	10.7 V/H	18.7 V/H	23.8 V/H	36.5 V/H		89.0 V/H		
	AMSU-A*				23.8 V/H	31.4 V	50.3-57.3 V/H	89.0 V		
	SSMI			19.4 V/H	22.2 V	37.0 V/H		85.5 V/H		
Type 3: High freq. channels	AMSU-B*							89.0 V/H	150.0 V	183.3 V
	MHS*							89.0 V/H	157.0 V	183.3 H/ 190.3 V
Type 4: All channels	SSMIS			19.4 V/H	22.2 V	37.0 V/H	50.3-63.3 V/H	91.7 V	150.0 V	183.3 H
	GMI		**10.7 V/H**	**18.7 V/H**	**23.8 V**	**36.5 V/H**		**89.0 V/H**	**166.0 V/H**	**183.3 V/H**
	ATMS*				23.8 V	31.4 V	50.3-57.3 V/H	88.2 V	165.5 H	183.3 H
Type 5: All except 183 channels	MADRAS			18.7 V/H	23.8 V	36.5 V/H		89.0 V/H	157.0 V/H	
Type 6: 183 channels	SAPHIR*									183.3 H

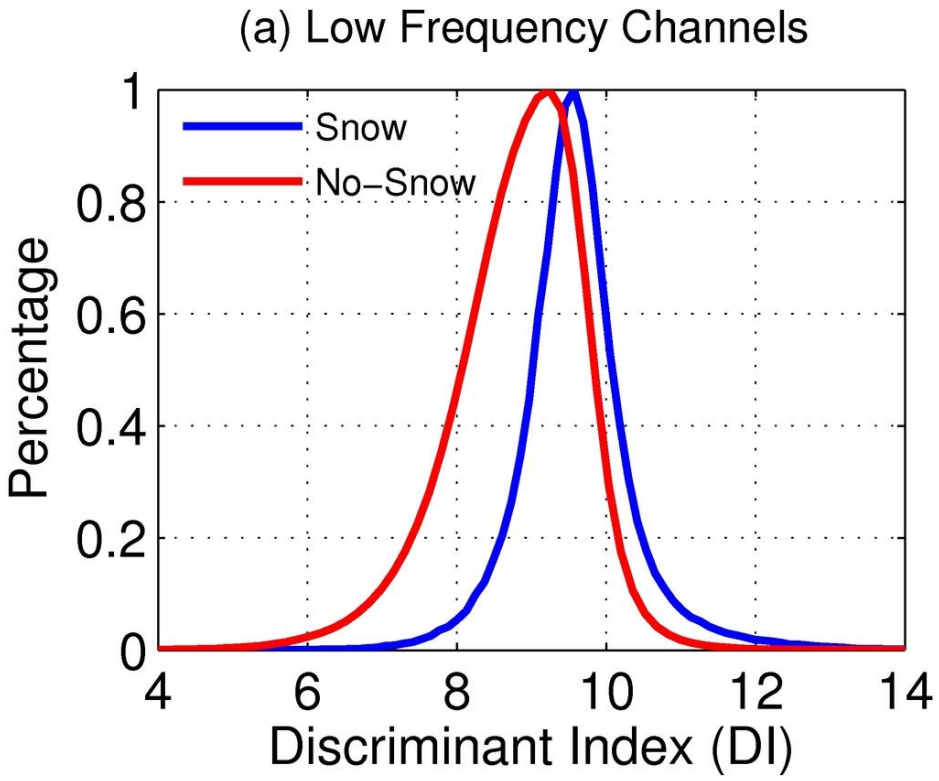
- Low freq. channels: central frequency < 85 GHz (e.g., 10, 19, 24, 37, 57 GHz)
- High freq. channels: central frequency ≥ 85 GHz (e.g., 85, 150, 166 and 183 GHz)

Methodology and Dataset

- Use the Linear Discriminant Analysis (LDA) approach (see Turk et al. 2014, JHM for more details)
- Compare the Probability of Detection (POD) for the same False Alarm Rate (FAR) at 0.1

- GMI TBs (from 10 to 183.3 GHz)
- KaPR and KuPR
- Ground gauge observations

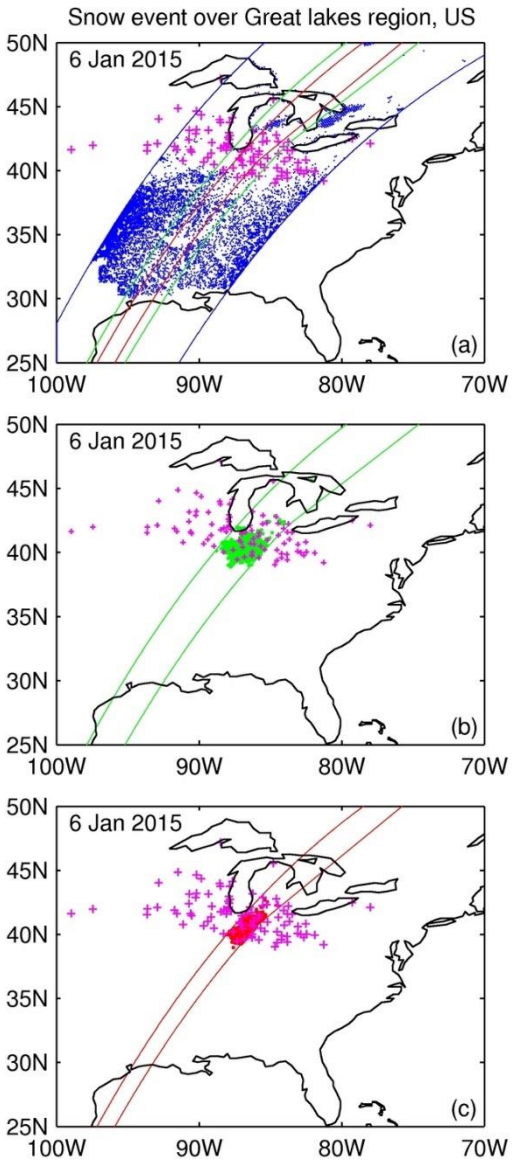
Snowfall detection performance of low freq. channels



- Low freq. channels: V10, H10, …, H37
- Two curves largely overlapped
- POD is 0.34

- Low freq. channels: central frequency < 85 GHz (e.g., 10, 19, 24 and 37 GHz)
- High freq. channels: central frequency ≥ 85 GHz (e.g., 85, 150, 166 and 183 GHz)

Snowfall detection performance of low freq. channels

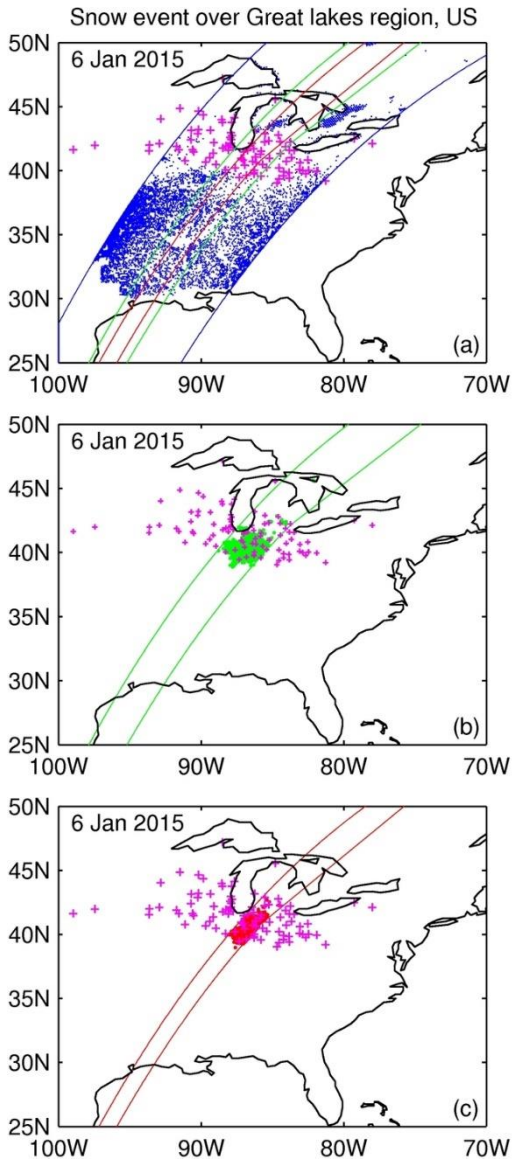


- Blue curve: GMI swath
- Green curve: KuPR swath
- Red curve: KaPR swath
- Magenta cross: surface gauge observation
- Blue dots: snowfall detected by low freq. channels

- Green dots: snowfall observed by KuPR

- Red dots: snowfall observed by KaPR

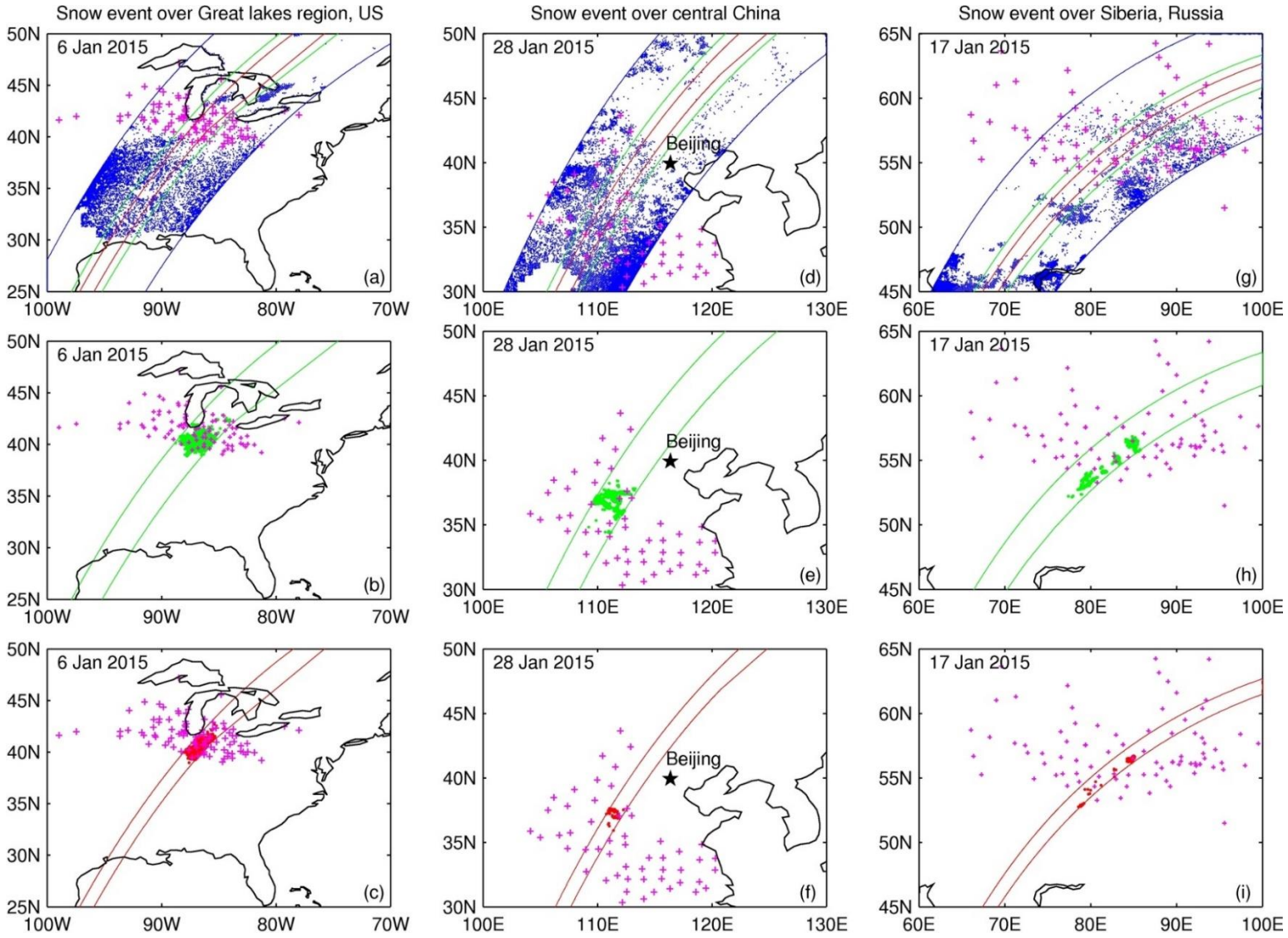
Snowfall detection performance of low freq. channels



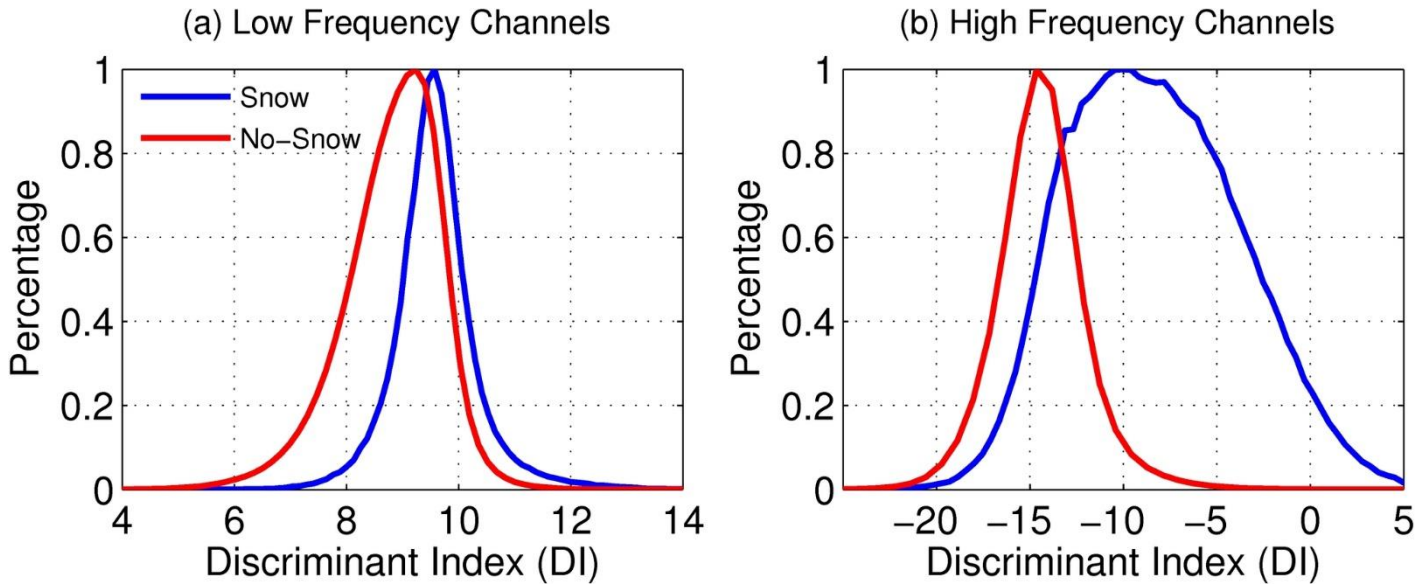
Conclusions:

- Miss the snowfall pixels
- Falsely identify snowfall pixels

Snowfall detection performance of low freq. channels

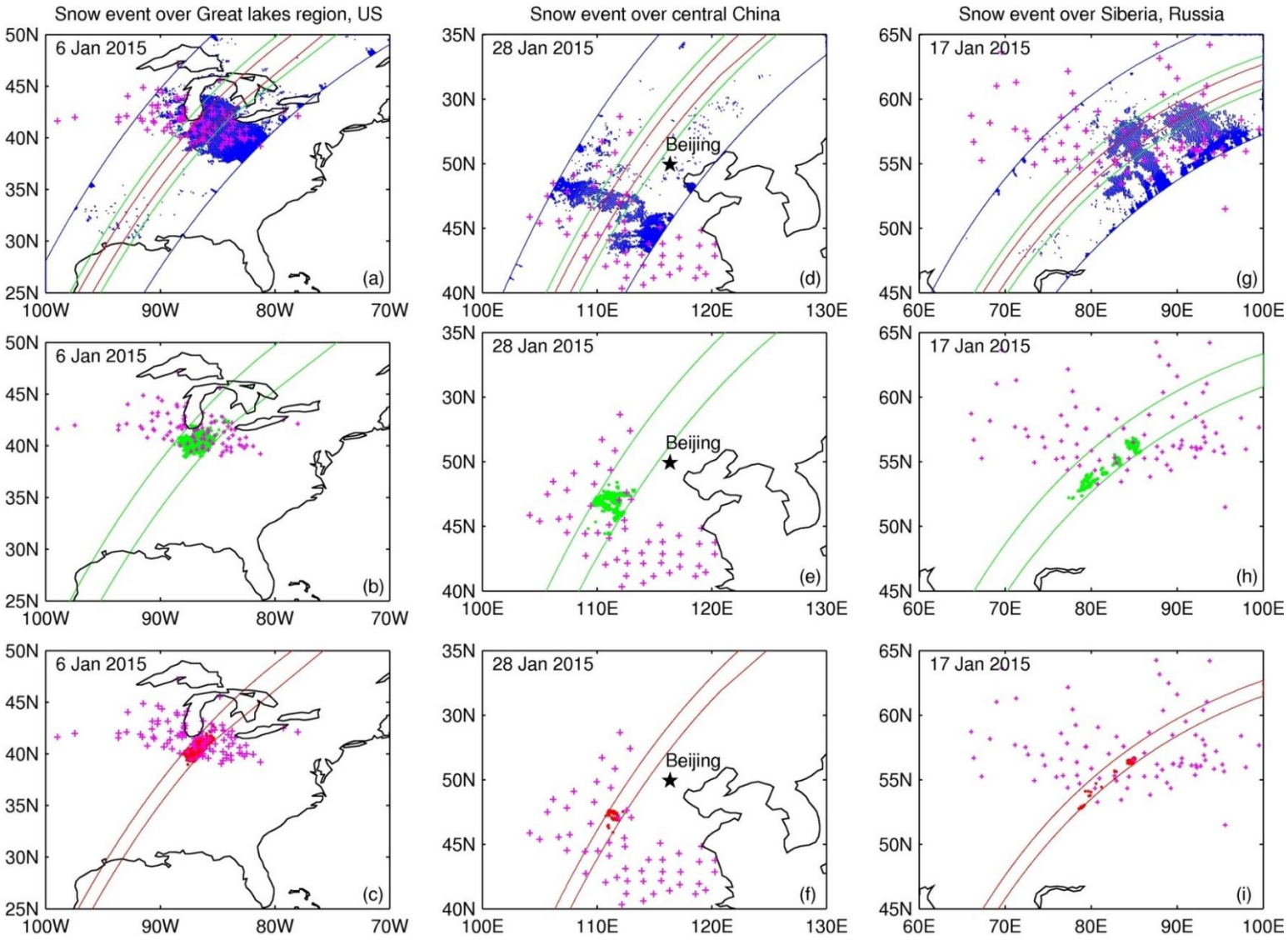


Snowfall detection performance of high freq. channels



- **Low freq. channels: POD is 0.34**
- **High freq. channels: POD is 0.74**

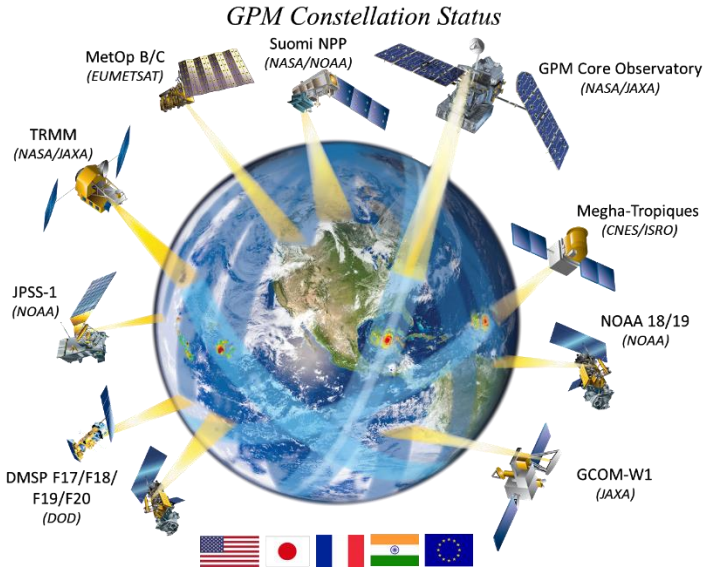
Snowfall detection performance of high freq. channels



Snowfall detection performance of high freq. channels

- High frequency channel: detected snowfall pixels agree with other instruments very well.

Snowfall detection capability of GPM constellation radiometers



Ideally:

- Collocate GMI constellation radiometers to a common reference
- Judge their snowfall detection capability.
- However, there is no such a reference on the global scale

Snowfall detection capability of GPM constellation radiometers

Our strategy:

- Group these 13 radiometers into six categories based on the channel availability (next slides)
- Use subsets of GMI channels to estimate the snowfall detection capability for these six types of radiometers

- the essential idea is not to obtain the exact POD value of each radiometer. Instead, the idea is to rank these six types of radiometer, which serve as "prototype" sensor types for future sensors that could be added to the constellation

Six types radiometers (channel availability)

Radiometer type`	Radiometer name	6-7 GHz	10 GHz	19 GHz	23 GHz	31-37 GHz	50-60 GHz	80-92 GHz	150-167 GHz	183-190 GHz
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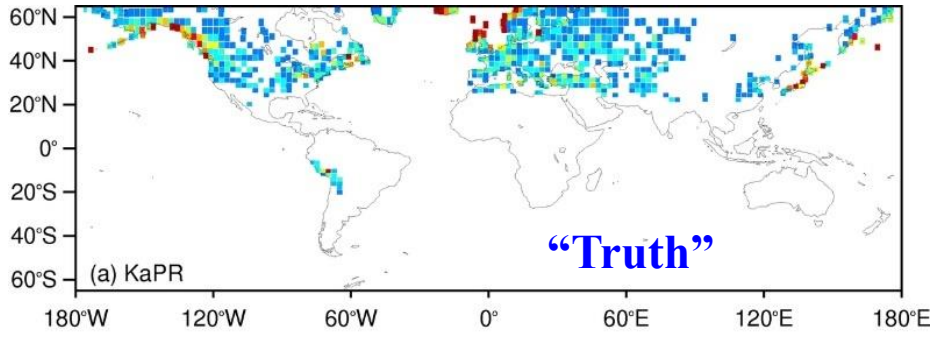
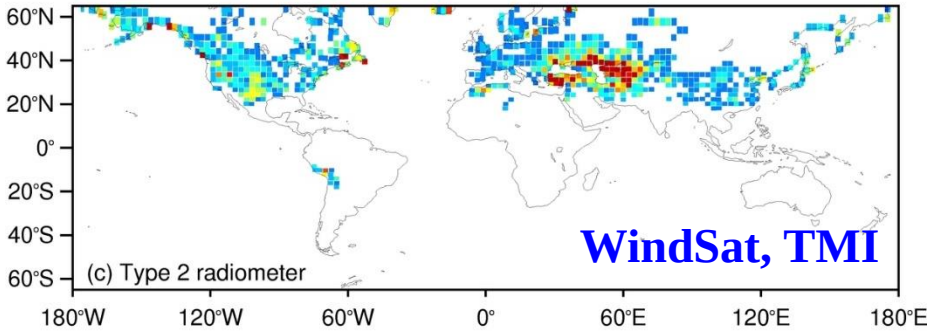
POD of GPM constellation radiometers

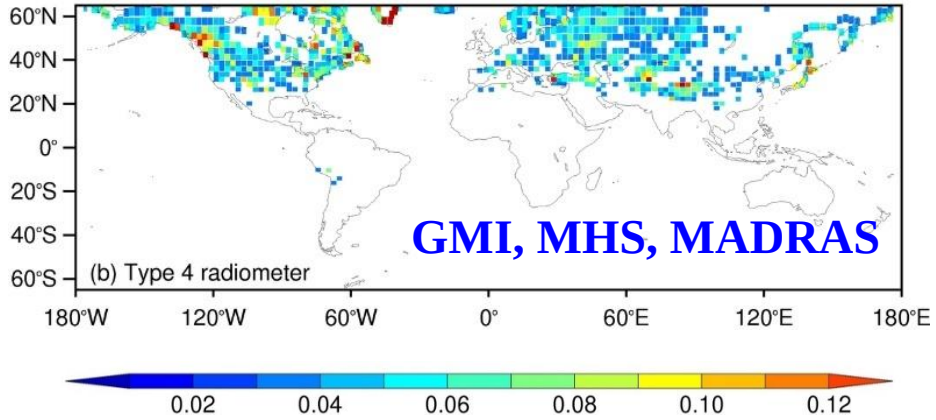
Radiometer types	POD	Typical radiometer	Channel availability
Type 1	0.33	WindSat	Low freq. channels
Type 2	0.43	TMI	Low freq. channels + 89 GHz
Type 3	0.74	MHS	High freq. channels
Type 4	0.77	GMI	All channels
Type 5	0.72	MADRAS	All channels except 183 channels
Type 6	0.13	SAPHIR	183 channels

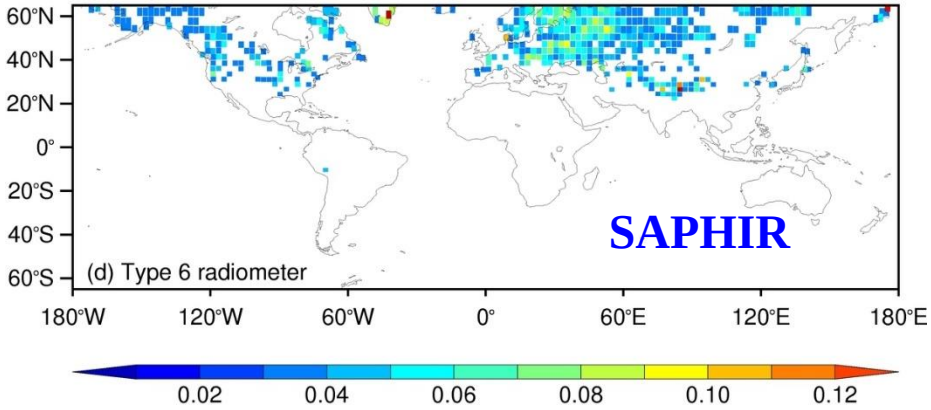
- Type 4 radiometer (e.g., GMI) has the best snowfall detection capability

Snowfall occurrence frequency of GPM constellation radiometers









- Type 3, 4 &5 radiometers: agree best with KaPR
- Type 1 & 2 radiometer (e.g., TMI): opposite snowfall geospatial distribution (i.e., higher snowfall occurrence in low latitude)
- Type 6 radiometer (e.g., SAPHIR): miss many snowfall pixels in North America and Asia

Water vapor effect vs. Ice scattering effect

Channel availability	POD
High freq. water vapor channels (183)	0.13
High freq. window channels (89, 166)	0.66
High freq. channels (89, 166, 183)	0.74

- Only water vapor information, the snowfall detection performance is very poor
- Only high freq. window channels, the snowfall detection performance is much better
- Combining these two signal sources achieves the optimal snowfall detection

Conclusions

- High freq. channels are indispensable for snowfall detection
- Water vapor channels are necessary to achieve the optimal detection performance
- Low freq. channels are of less importance

- Type 4 radiometer (GMI, SSMIS, ATMS) has the best snowfall detection capability
- Type 3 and 5 radiometers (MHS and MADRS) slightly worse

- Expand this work to ocean and in-land waters & combine DPR with CloudSat for a more complete dataset

Comments and Questions